and it is never at all depressingly a "cure" place. It has too much space and freedom for that, and there is on the part of the management a vivid realization that the invalid wants comfort as well as cold water for his restoration to health—the comfort of a good French cuisine, good bed, good attendance, and a cleanliness that is perfection.

BACTERIA IN THEIR RELATION TO HEALTH AND DISEASE *

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By the term "sterilization" is meant the destruction of bacteria by heat. This may be accomplished in two ways,—either by dry heat or by moist heat in the form of steam. Dry heat has a relatively limited application, as the temperature must be higher and the exposure longer than when moist heat is used. Knives, needles, scissors, and other metal instruments may be sterilized by direct heating in the open flame, a moment only being required. For objects that cannot be submitted to the direct action of the flame and yet can withstand prolonged heating at high temperatures, such as test-tubes, glass plates, microscope slides, and cover-glasses, the sterilizing-oven is used. Here we must obtain a temperature of at least 300° F., and maintain it for not less than one hour. The reason for this prolonged exposure to such a high temperature is that, while bacteria in their common form are not particularly able to withstand moderately high temperatures, the fruits or spores, about which we shall learn more soon, are perhaps the most tenacious of life among all the organized beings of the world. Of course, if the spores be not killed, the instrument is not sterile, as when suitable conditions of moisture and nutriment are supplied these spores will rapidly develop into bacteria.

Sterilization by steam is practised with all culture-media,—the substances in which bacteria are grown for purposes of observation. These culture-media, composed largely of decomposable organic materials, would be rendered entirely worthless if exposed to the dry method of sterilization. So too with cotton and woollen fabrics, bedding, clothing, etc. The penetrating power of steam is far greater than that of dry heat. Spores which resist the action of dry heat at very high temperatures for a long

* Read before the nurses of Rochester City Hospital in 1892.

time are killed by a few minutes' exposure to steam. Steam when freely escaping has the temperature of boiling water—212° F. Substances exposed to a current of steam for half to three-quarters of an hour are rendered sterile. Now, there are some substances, such as blood serum, which cannot be raised to the boiling-point without destroying their usefulness as culture-media. For such substances the method of "discontinuous sterilization," as it is called, is employed. As already stated, bacteria in the growing stage are much more easily killed than in the resting or spore stage. If a medium be exposed to a temperature of 130° to 140° F. for three or four hours, all of the growing bacteria are killed. If now it is kept in a room at a comfortable living temperature, the spores, which were *not* killed, will develop into bacteria. After twenty-four hours these newly-formed bacteria are killed at the same temperature employed the day before and the medium is again set aside for further development. It has been found that such intermittent sterilization kept up daily for a week is sufficient to render the medium absolutely sterile, if it has been properly protected from contamination from without. This is best done by stopping the mouth of the vessel containing the medium with a good plug of common cotton wool. Cotton wool if kept dry is a good germ-filter without any special preparation. It admits the air, but holds back the bacteria. Test-tubes, flasks, bottles, and other glass vessels are provided with these plugs in advance, and then all sterilized together by placing in the dry oven. Then as long as the cotton plug is in place the vessel is sterile on the inside.

Bacteria, except a few of the more dainty pathogenic forms, are able to subsist on almost any kind of nutriment, especially if it has a slightly alkaline reaction. In searching for the most suitable culture-medium it was found that beef-tea furnishes the most acceptable nutriment to the vast majority of the bacteria. This has to be prepared in a special way to be sure that it may be perfectly transparent and of the proper reaction. And so for our recipe we must go not to Mrs. Rorer, but to Robert Koch.

But with fluid media alone progress would be slow and extremely laborious, owing to the difficulty of isolating single species. It was observed that slices of boiled potato left exposed to the air for a time and then kept a day or two where they could not dry up were dotted here and there with small white-colored points which increased quickly in extent until they at length covered the whole slice. These were found to be collections of micro-organisms, and, further, it was found that each point contained only bacteria of one and the same kind. The acuteness of Koch enabled him to realize the advantages of this isolation of species. Soon the brilliant idea occurred to him of combining the advantages of

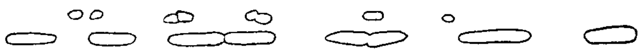
solid and fluid media in one, and at the same time getting rid of the disadvantages of both. This he did by changing the liquid media into solid ones by the addition of a transparent substance capable of consolidation. This substance is *gelatin.* It melts at about 75° F., and at higher temperatures is perfectly fluid. Then it returns to the solid state at temperatures below 75° F. and forms an almost colorless mass of glassy transparency and jelly-like consistency. When this substance is added to the beef-tea we have the medium known as "nutrient gelatin." Instead of gelatin another substance may be employed. It is called *agar-agar,* and is a vegetable jelly obtained from sea-tangle on the coasts of India and Japan. It remains solid at much higher temperatures than does gelatin, and so is more suitable for the study of those bacteria which require high temperatures for their development,—such as many pathogenic bacteria which thrive only at the temperature of the human body. There are many other special media employed for various purposes, but those already mentioned are the most common and most useful.

It was with nutrient gelatin that Koch developed his "plate process" for isolating species and obtaining "pure cultures." Fluid nutrient gelatin or agar-agar is poured into a number of sterilized test-tubes. Into one of these tubes is put a drop of the substance containing masses of the bacteria to be studied. This is thoroughly mixed with the medium and then by means of a sterilized platinum hook a drop of this mixture is put into tube No. 2, and from No. 2 a drop is transferred to No. 3. It will be readily seen that the number of bacteria in No. 3 is far less than that in No. 2, and that No. 2 contains but a small fraction of the number in the original tube. While still fluid and after the above "inoculation," as it is called, the media in Nos. 2 and 3 are poured out on cooled glass plates and spread in an even, thin layer. The plates are protected from the air and kept at suitable temperature and moisture for growing bacteria until the colonies are seen to be developing. On the plate made from tube No. 3 the colonies will probably be so few that they will be widely separated and may be studied individually. There will be as many colonies as there were bacteria poured out on the plate, each bacterium being separated from the others and starting a separate colony. This shows the necessity for great dilution of the first mixture of bacteria. If now from one of these growing colonies a bit can be picked out with a sterilized platinum needle and planted in a tube of nutrient gelatin uncontaminated by other bacteria, we will have in this last tube a "pure culture" of the bacterium, and from this we are able to grow this species by itself as long as we wish for purposes of study. This, in short, is the way in which bacteria are isolated for purposes of investigation. There are many modifications of the details

of the process, but all aim at the same object,—getting pure cultures, without which bacteriology would be in the same chaotic state it was in before Koch and Pasteur began their work.

Colonies of bacteria may be examined by the low powers of the microscope just as they are growing on the plates or in the tubes. Or a few of the bacteria may be picked out of a colony on the point of a sterilized needle and mounted on slides and cover-glasses for more minute examination with the aid of the highest powers. Again, bacteria are found to take the anilin dyes readily and are much more easily seen under the microscope when stained. But when stained they are killed, and to study processes of growth they must be observed unstained.

By these and other methods of observation it has been discovered that bacteria multiply by fission. That is, the cell stretches out in the direction of its length, the limiting membrane pushes a partition wall into the interior, and soon there are two germs where one existed before.



These again divide, and so the process is continued as long as the circumstances are favorable to growth.

Under certain conditions of nutrition and growth bacteria are able to propagate by another means than that of cell-division. In a number of bacilli and in a few spirilla the formation of spores has been observed. One cell forms but one spore under all circumstances. It may appear in the middle  or at one end of the rod.  Spores stain only with great difficulty. As already stated, they cling very tenaciously to life. When the conditions are favorable, these spores may be seen to develop into new bacilli which go on multiplying by division like all others of their kind.

Many of the rod- and screw-shaped bacteria possess the power of spontaneous movement. This motion is produced by means of very delicate cilia or flagella, with which they are provided. Scientists were confident of the existence of these delicate appendages a long time ago. They were actually demonstrated only recently by means of a special process of staining devised by a German scientist named Löffler.

By adding a solution of litmus to test-tubes containing nutrient gelatin and then inoculating them with different species of bacteria, it has been found that some micro-organisms in growing produce very considerable quantities of acid, others of alkali. Ammonia, sulphuretted hydrogen, and other gases are formed by some bacteria. It was Pasteur who first proved that fermentation is produced by the action of certain

bacteria. Putrefaction also depends upon the action of bacteria. Other bacteria enter into living organisms, grow and multiply in them, and produce poisons which are the causes of those diseases which we know under the name of "infectious diseases."

(To be continued.)

HYGIENE OF THE HOUSEHOLD

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(Continued from page 351)

ONE important feature in the arrangement for a surgical operation is the sterilizing of water, towels, instruments, and other appliances.

In regard to the water, both hot and cold boiled water will be required, unless Hygeia water is provided to take the place of the latter.

You cannot err in having ready a good supply of sterilized water, as an emergency may arise in which a double quantity would be required. Clean the wash-boiler thoroughly, fill it almost to the top, and boil for half an hour. One boilerful must be prepared in time for the water to grow cold before the operation; it is then poured into pitchers that have been washed in warm soapsuds and rinsed off with the sterilized water. Cover the pitchers with sterilized towels.

The second boilerful is carried direct to the operating-room about twenty minutes before the surgeon arrives.

As to the wet and dry sterilized towels, two dozen are pinned up in an old towel or piece of sheeting and put on a dish into the oven for two or three hours; keep the oven at a moderate heat, and look at the towels occasionally to be sure they are not burning. The remaining two dozen towels are fastened in an outside covering and put in a granite pot or dishpan, with a plate in the bottom; cover completely with water and boil for one hour. When the nurse's hands are sterilized, the towels are removed from their outer covering, and the wet ones are wrung out, opened from the folds, and laid in a sterilized basin to be ready at a moment's notice. As a rule, the surgeon's assistant attends to the instruments, but if the nurse is called upon to sterilize them and has no regular sterilizer at hand, tie them up in a towel or piece of cheese-